IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(MBHB 09-333-US)

In re Application of: William J. Carroll	)	Group Art Unit: 3762
Serial No.: 10/761,424	)	Examiner: Stoklosa, Joseph A.
Filed: January 22, 2004	)	Confirmation No.: 1421
For: Spinal Cord Stimulation with Interferential Current	)	

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF THOMAS L. YEARWOOD, MD PHD, UNDER 37 CFR § 1.132

Dear Sir:

I, Dr. Thomas L. Yearwood, declare as follows:

I. Background

1. I am a doctor licensed to practice in Alabama (no. 15545), Mississippi (no. 11988), and Louisiana (no. 17377). I am currently practicing medicine at Comprehensive Pain and Rehabilitation in Daphne, AL and Pascagoula, MS. My practice is devoted full-time to the field of Pain Medicine, with a primary clinical mode of implantation therapy. I have been a practicing doctor for 28 years.

2. I have been the primary implanting physician on over 2,000 Intraspinal neurostimulator devices over the past 15 years.

3. I am an active consultant for three neurostimulator device manufacturers, and am actively involved in clinical trials for various implantable devices. I further am actively involved in neurostimulator lead design.

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001

4. I obtained a bachelors degree from Tulane University in Engineering in 1973. I obtained a masters degree from Tulane University in Mechanical Engineering in 1974, and a doctorate of philosophy (PhD) from Tulane University in Bioengineering in 1979. I obtained a medical degree (MD) from LSU School of Medicine in 1983, and received the Chancellor's Award. I performed my internship in the department of surgery at the University of Washington Affiliated Hospitals in Seattle, Washington from June 1983 to June 1984. I performed my residency in the department of surgery at the University of Washington Affiliated Hospitals in Seattle, Washington from June 1984 to June 1986. I performed a second residency in the department of anesthesiology at the University of Texas Medical Branch in Galveston, Texas from June 1986 to December 1988. I am a member of the AOA Honor Medical Society. I have board certification for the following boards: American Board of Anesthesiology (April, 1990), ABA, Special Qualifications in Pain Management (1996, 2006), and American Board of Pain Medicine (2000, 2010).

5. I have authored or co-authored the following publications:

Research Articles / Publications:

Yearwood TL, Hershey B, Bradley K, Lee D., Pulse Width Programming in Spinal Cord Stimulation: A Clinical Study. *Pain Physician* 2010; 13:321-335.

Yearwood TL, Neuropathic Extremity Pain and Spinal Cord Stimulation. *Pain Medicine* Volume 7, Issue Supplement s1, pages S97–S102, May 2006.

Yearwood TL, Tackett HS, Bridges B., Intradiscal Pressure Tolerance before and after Gray Ramus Communicans Blockade In Primary Discogenic Pain. AAPM Annual Meeting Poster Session, Thursday, 23 February 2006.

Staats PS, Yearwood TL, Charapata SG et al., Intrathecal Ziconotide in the Treatment of Refractory Pain in Patients With Cancer or AIDS: A Randomized Controlled Trial. *JAMA*. 2004;291(1):63-70.

6. I am qualified to make this declaration based on my experience as a doctor and implanting numerous stimulator devices in patients, my experience with consulting and design of stimulator devices, my knowledge of the medical device sector, and my familiarity with existing devices and the history of spinal cord pain management.

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001

II. Opinion with respect to U.S. Patent Application Publication No. 2004/0167584

7. I have read U.S. Patent Application Publication No. 2004/0167584 ("the patent application"), filed on January 22, 2004 titled "Spinal Cord Stimulation With Interferential Current".

8. It is my interpretation that the patent application describes an electrical stimulator for the treatment of intractable pain syndromes that includes implantable electrodes implanted to a dura mater proximate to a subject's spinal cord, and interferential stimulation is used to produce a beat frequency signal such that a majority of the beat frequency signal is directionally controlled to avoid stimulating adjacent and/or inappropriate neuronal targets within the spinal canal, thereby creating a far more efficacious neurostimulation field in the treatment of pain.

9. The patent application describes that an effective area of stimulation is controlled by the quantity of electrodes, positioning of the electrodes and electrode cross pattern orientation. (the patent application, Abstract). Based on this disclosure, it is my understanding that the beat frequency signal can be directionally controlled.

10. The patent application describes that traditional Dorsal Column neurostimulation, which does not use interferential currents, stimulates the Dorsal Column in a somewhat superficial manner. (cf: Holsheimer J: Which Neuronal Elements are activated Directly by Spinal Cord Stimulation, *Neuromodulation*, Volume 5, Number 1: 25-31,2002).

11. The patent application describes that in traditional SCS stimulation, the electrodes are normally attached to the dura mater in the epidural space, and most of the current distribution remains in the cerebrospinal fluid (CSF) and does not project deeply into the dorsal column. [0006]. Based on this disclosure, it is my understanding that traditional SCS stimulation without the use of interferential currents has limited application because of the spread of the stimulating electrical field within the CSF as intensity of stimulation increases. This is due to the highly conductive nature of the CSF as compared to the less conductive nature of the spinal cord tissue itself. Thus, neurostimulation without interferential current capability is "amplitude limited" to a relatively narrow surface area of the spinal cord. Frequently, patient satisfaction with the electrical stimulation is compromised by the recruitment

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001

of adjacent neuronal structures that, when activated, can create discomfort, motor contractions, and outright pain. Thus, the efficacy of the therapy is limited.

12. The patent application describes that in traditional SCS stimulation, the electrodes are normally attached to the dura mater in the epidural space, and most of the current distribution remains in the cerebrospinal fluid (CSF) and does not project deeply into the dorsal column. [0006]. The patent application also states that providing an interferential component to the electrode array of the SCS allows the crossing of the two signals wherein the resultant additive effect of the beat frequency produces deeper penetration of the signal and a higher resultant amplitude at the stimulation site, and that the interferential current would recruit larger numbers of dorsal column fibers and provide greater levels of pain relief and benefit to intractable pain patients. [0006]. Based on this disclosure, it is my understanding that using an electrical stimulator that includes electrodes implanted upon the dura mater with interferential currents produces a beat frequency signal that has deeper penetration than that possible using traditional SCS stimulation, and a majority of the beat frequency signal can be more precisely controlled in terms of direction and depth of tissue penetration proximate to the subject's spinal cord. Thus, interferential current would recruit larger numbers of dorsal column fibers and potentially provide greater levels of pain relief and benefit to intractable pain patients.

13. Further, based on the disclosure in paragraph 0006 of the published patent application, it is my understanding that providing an interferential component to the electrode array of the SCS allows the crossing of the two signals such that the resultant additive effect of the beat frequency produces deeper penetration of the signal and a higher resultant amplitude at the stimulation site because only sub-threshold signals, of minimal biological consequence, remain in or shunt through the CSF.

14. Based on the disclosure in the patent application, the available extant literature in the field of neurostimulation, my understanding of the laws of electrophysics as pertains to biological systems, and my considerable clinical experience, it is my understanding that neuronal tracts that lie beneath the surface of the Dorsal Columns (i.e., >0.5 mm) can be successfully stimulated using an interferential pattern of electrical fields. This capability substantially widens the therapeutic utility of SCS, and in ways not limited to the Dorsal Columns alone.

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001

The interferential capability allows for more precise neurostimulation of the adjacent Dorsal root Entry Zone at one level, with complementary stimulation of the corresponding neuronal tracts deep within the Dorsal Columns at a different level (depending on the ultimate lead design). Other applications include highly precise neurostimulation of the nerve roots and the Dorsal Root Ganglia themselves, all from an intraspinal, epidural location. This ability for control of neuronal stimulation from a three-dimensional perspective is potentially of considerable importance in advancing the clinical capabilities of neurostimulation within the spinal canal, and beyond.

15. The patent application describes that using Interferential current in SCS provides for improved directional control and depth of penetration of the beat frequency signal in comparison to other stimulation techniques. [0008]. It is my understanding that by generating the beat frequency signal, the resultant additive signal is directionally controlled to avoid cerebrospinal fluid proximate to the subject's spinal cord.

16. The patent application describes that an Interferential current in SCS recruits larger numbers of dorsal column fibers and provides greater levels of pain relief in comparison to other SCS techniques. [0018]. It is my understanding that as a result of recruiting larger numbers of dorsal column fibers by using Interferential current and by generating a beat frequency signal, the patients could potentially experience greater levels of pain relief.

17. The patent application describes that multiple target areas of the spinal cord can be treated depending upon the quantity and placement of the first and second pairs of electrodes, and by modulating the amplitudes of the outputs of the first and second circuits as shown in Figure 3. [0020]. It is my understanding that to target specific areas of the spinal cord using modulation of the circuit outputs, the resultant beat frequency signal would be directionally controlled and/or depths of penetration are controlled.

18. The patent application describes that modulating the outputs of the first and second circuits increases the area of the targeted stimulation, and that by enabling control of the depth of modulation, a beat frequency signal can be distributed and controlled to avoid neurostimulation of clinically inappropriate neuronal tracts proximate to the subject's spinal cord. [0020].

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001

19. The patent application describes that it has been shown that when the first and second circuits intersect at 90°, the maximum resultant amplitude and the deepest level of modulation is half-way between the two circuits as illustrated in Figure 2. [0020]. It is my understanding that to target specific areas of the spinal cord using modulation of the circuit outputs, the resultant beat frequency signal would be directionally distributed and controlled three-dimensionally.

20. Based on the entirety of the disclosure in the patent application, it is my opinion that the patent application describes an electrical stimulator that uses interferential current provided via implantable electrodes to produce a beat frequency signal such that a majority of the beat frequency signal is directionally distributed and controlled to avoid remaining in and shunting through the cerebrospinal fluid proximate to the subject's spinal cord.

II. Opinion with respect to Experimental Study Performed with an example Electrical Stimulator of U.S. Patent Application Publication No. 2004/0167584

21. I have read the report of the study that was performed in the Neuronano Lund Research Center University in Sweden by Marcus Granmo and Jens Schouenborg with the electrical stimulator of the present application. A copy of the study report is included as Exhibit B. The study demonstrates that using the interferential electrical stimulator of the present application, a beat frequency is obtained that provides deep and localized stimulation.

22. The study in Exhibit B included an experimental setup as follows:

(a) Two pairs of stimulation electrodes (bipolar stimulation, 4 electrodes in total) were placed epidurally (to a dura mater in an epidural space) on the spinal cord in two configurations; (i) a crossed and (ii) a parallel configuration (*See*, e.g., Figures 1 and 2 of Exhibit B).

(b) Recording microelectrodes were inserted in the Gracile nucleus and the Pyramid tract in the brainstem (*See*, e.g., Figure 1 of Exhibit B). The recording electrodes do not provide stimulation to the Gracile nucleus and the Pyramid tract. Simultaneous recordings from the

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001

Gacile nucleus and the Pyramid in the brainstem render easy comparison of the effect of stimulation. (Exhibit B, "Project Outlines").

III. **Opinion with respect to U.S. Patent No. 5,643,330 (Holsheimer) and U.S. Patent No. 5,512,057 (Reiss)**

23. I have read the patent to Holsheimer. It is my opinion that using the apparatus described in Holsheimer, most of the pulse applied by the electrode stimulators would remain in the CSF, as shown in Figures 8, 11, 13 and 15. Holsheimer describes reducing the shunting effect by using electrodes with a large contact separation – larger than the thickness of the dorsal cerebrospinal fluid layer. (col. 5; lines 62-67), (col. 6; lines 1-9), *See* also Fig 4A.

24. It is my opinion that using the apparatus described in Holsheimer, the signals cannot be directionally controlled into the spinal cord. Instead, the signals are timed such that a field is generated for the recruited area only along the surface of the spinal cord. (col. 6; lines 30-35).

25. It is my opinion that using the apparatus described in Holsheimer with interferential currents (quadripolar stimulation with the electrodes configured in a criss-cross array) would not be possible because the action potential field that Holsheimer's apparatus generates is dependent upon configuring the electrodes in a transverse plane (col. 6; lines 52-55); (in contrast to configuring the electrodes in a sagittal plane, as shown in Fig. 3 of the present application).

26. Holsheimer describes a system in which a field is generated for the recruited area only along the surface of the spinal cord rather than into the spinal cord. (col. 6; lines 30-35).

27. I have read the patent to Reiss. It is my opinion that one of ordinary skill in the art would not modify the system in Reiss with electrodes implanted upon the dura mater as described by Holsheimer because Reiss is not used for dorsal column stimulation, and thus, implanting the electrodes in Reiss upon the dura matter does not make sense.

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001

28. Reiss is directed to surface stimulation, and thus, describes using currents having intensity values orders of magnitude larger than can be used with dorsal column stimulation.

29. Reiss does not describe how or where any electrodes would be implanted, or how the system could be operated using implantable electrodes such that an intensity of the current would be within acceptable levels (that do not cause pain) while still providing effective therapy to the patient.

30. It is untrue that with any application of interferential therapy, electrodes can simply be implanted, and the therapy can be scaled down so that intensity values of the current would be within acceptable levels (that do not cause pain) while still providing effective therapy to the patient.

31. In my opinion, based on the disclosure in Reiss, it is unknown if the system in Reiss would work if the electrodes were implanted. For example, Reiss does not describe how to scale down the intensity values of the current within acceptable levels (that do not cause pain) and to still provide effective therapy to the patient.

32. With the system of Reiss modified to use implantable electrodes, the positioning of the electrodes and the electric field provided by the electrodes would have to be controlled in a way such that the electric field present in the CSF does not spread around the spinal cord. CSF is much more conductive than spinal cord tissue. Thus, if current is not controlled, the current will flow around the spinal cord. Reiss does not describe how to provide this effective therapy to the patient.

33. The electrodes as described in Reiss are not the proper type of electrodes for implantation, and thus, one of ordinary skill in the art would not implant the electrodes in Reiss.

34. The electrodes in Holsheimer cannot be used with the interferential current system in Reiss because the electrodes in Holsheimer's apparatus generate a field dependent upon configuring the electrodes in a transverse plane, in contrast to configuring the electrodes in a sagittal plane, as shown in Fig. 3 of the present application.

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001

35. As a practicing doctor, I would not modify the system in Reiss to include implantable electrodes so as to provide a possible improvement if the system in Reiss was not providing effective therapy. Reiss is directed to a first stage of physical therapy for back pain (e.g., surface therapy). In contrast, implantable stimulators are only used as a last resort, when all other physical therapy options have been unsuccessful. The difference between use of Reiss' surface stimulator and Holsheimer's implantable spinal cord stimulator amounts to years of treatment, and ultimately, implantation is only used as a last result. The technologies and applications described in Reiss and Holsheimer are thus vastly different.

36. Implantation is not the next step after failed surface stimulation, and I would not modify the system in Reiss to include implantable electrodes to improve effectiveness of the system in Reiss.

I further declare that all statements made herein of my own knowledge are true and that all statements made herein on information and belief are believed to be true, and that all statements are made with the knowledge that willful false statements are punishable by fine or imprisonment or both (18 U.S.C. § 1001) and may jeopardize the validity of the application or any patent issuing thereon.

Respectfully Submitted,

Date: 3/7/2011

By : Thomas L. Yearwood, MD, PhD

Signature: _____

Title: Pain Physician

McDONNELL BOEHNEN
HULBERT & BERGHOFF LLP
300 SOUTH WACKER DRIVE
CHICAGO, IL 60606
(312)913-0001